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(54) **ADAPTIVE SECTORIZATION IN CELLULAR SYSTEMS**

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See application file for complete search history.

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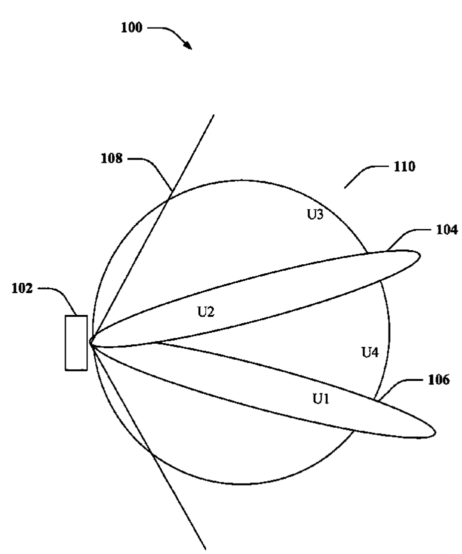
(57) **ABSTRACT**

Apparatuses and methodologies are described that enhance performance in a wireless communication system using beamforming transmissions. According to one aspect, a set of transmit beams are defined that simultaneously provides for space division multiplexing, multiple-input multiple output (MIMO transmission and opportunistic beamforming. The addition of a wide beam guarantees a minimum acceptable performance for all user devices.

45 Claims, 10 Drawing Sheets



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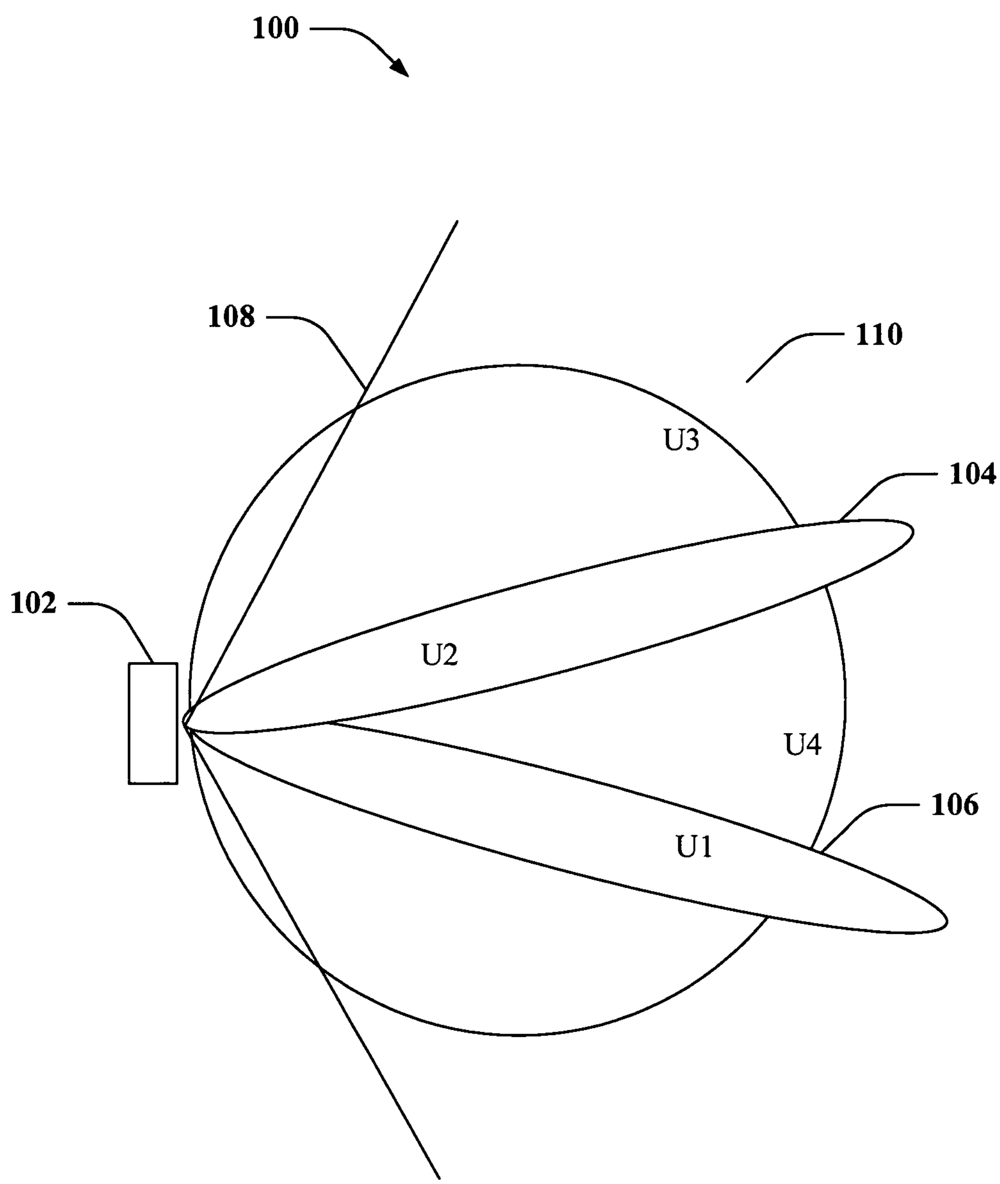


FIG. 1

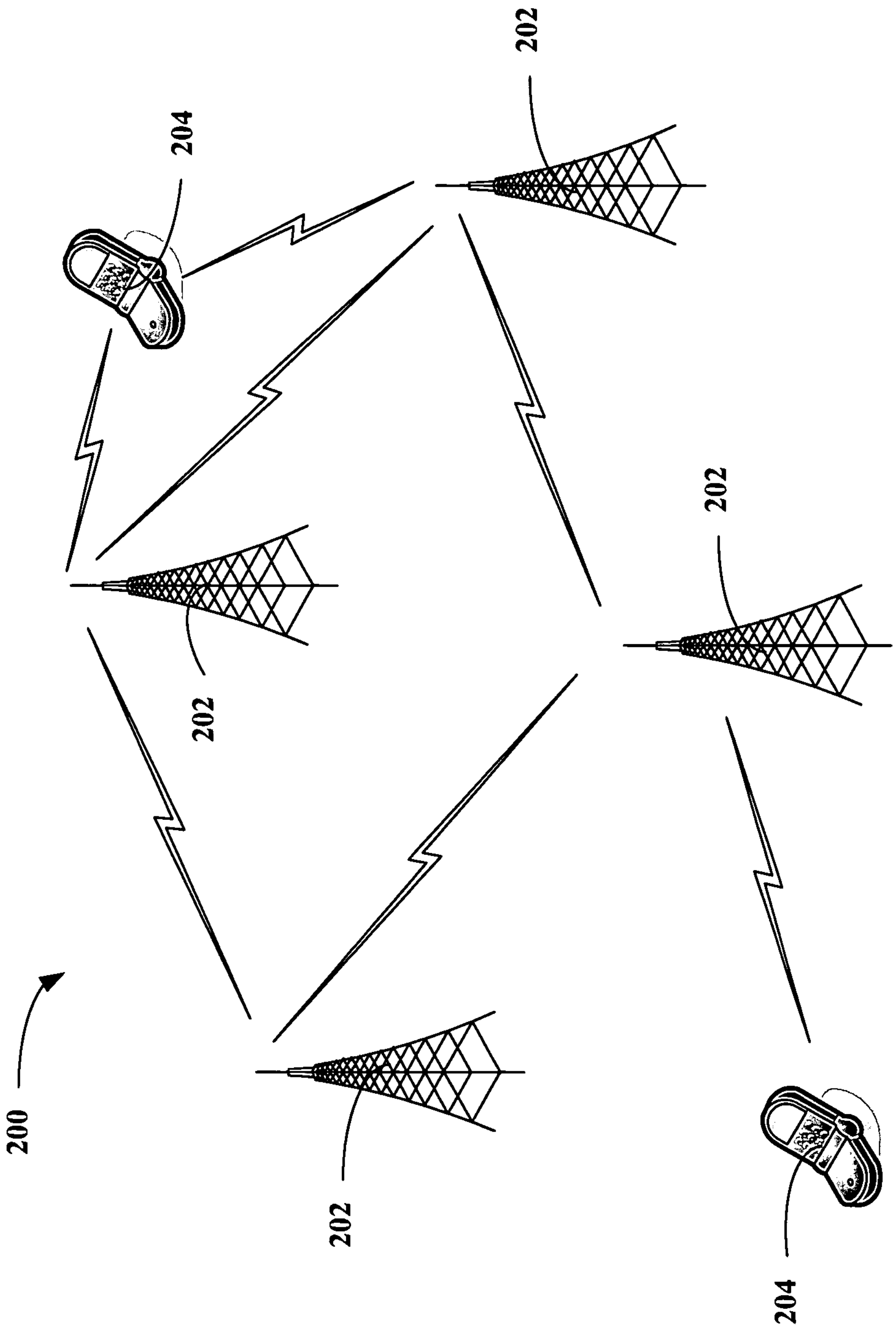


FIG. 2

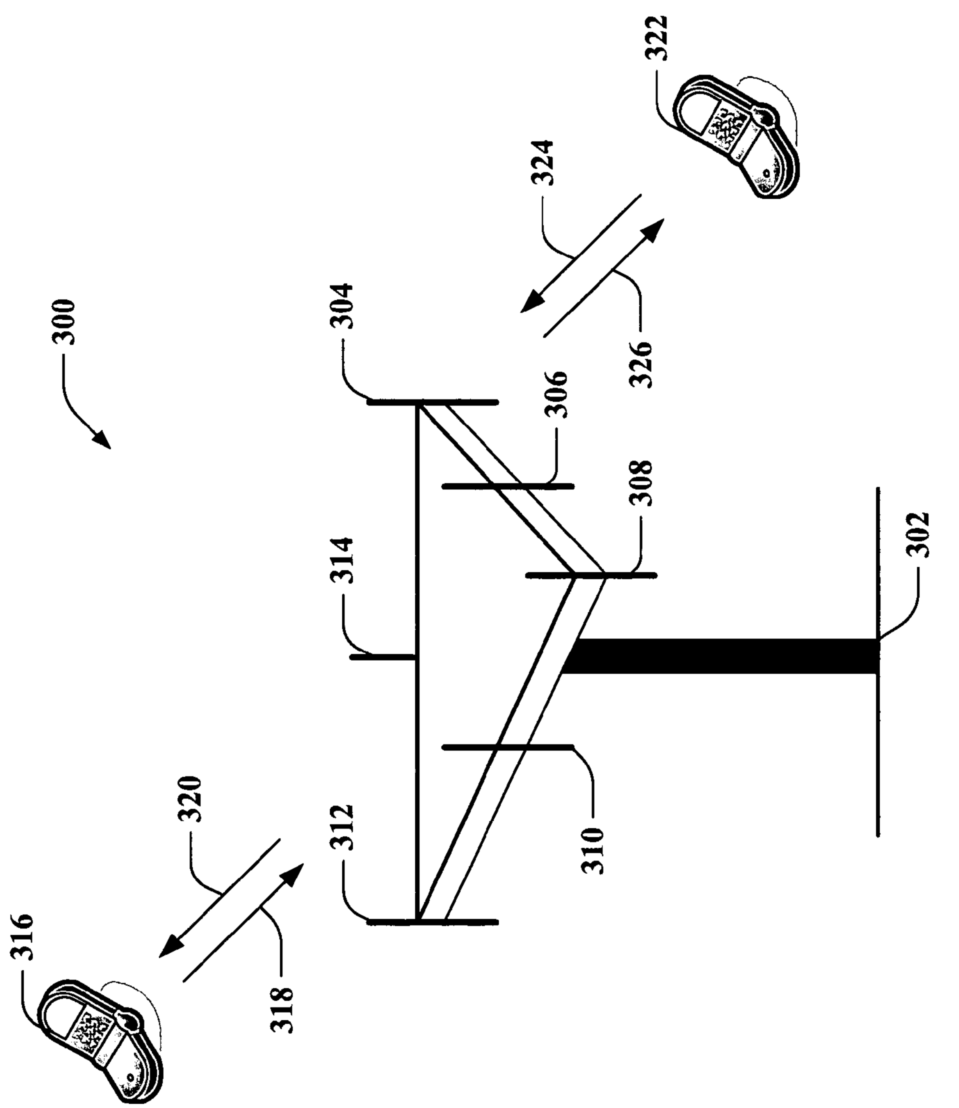
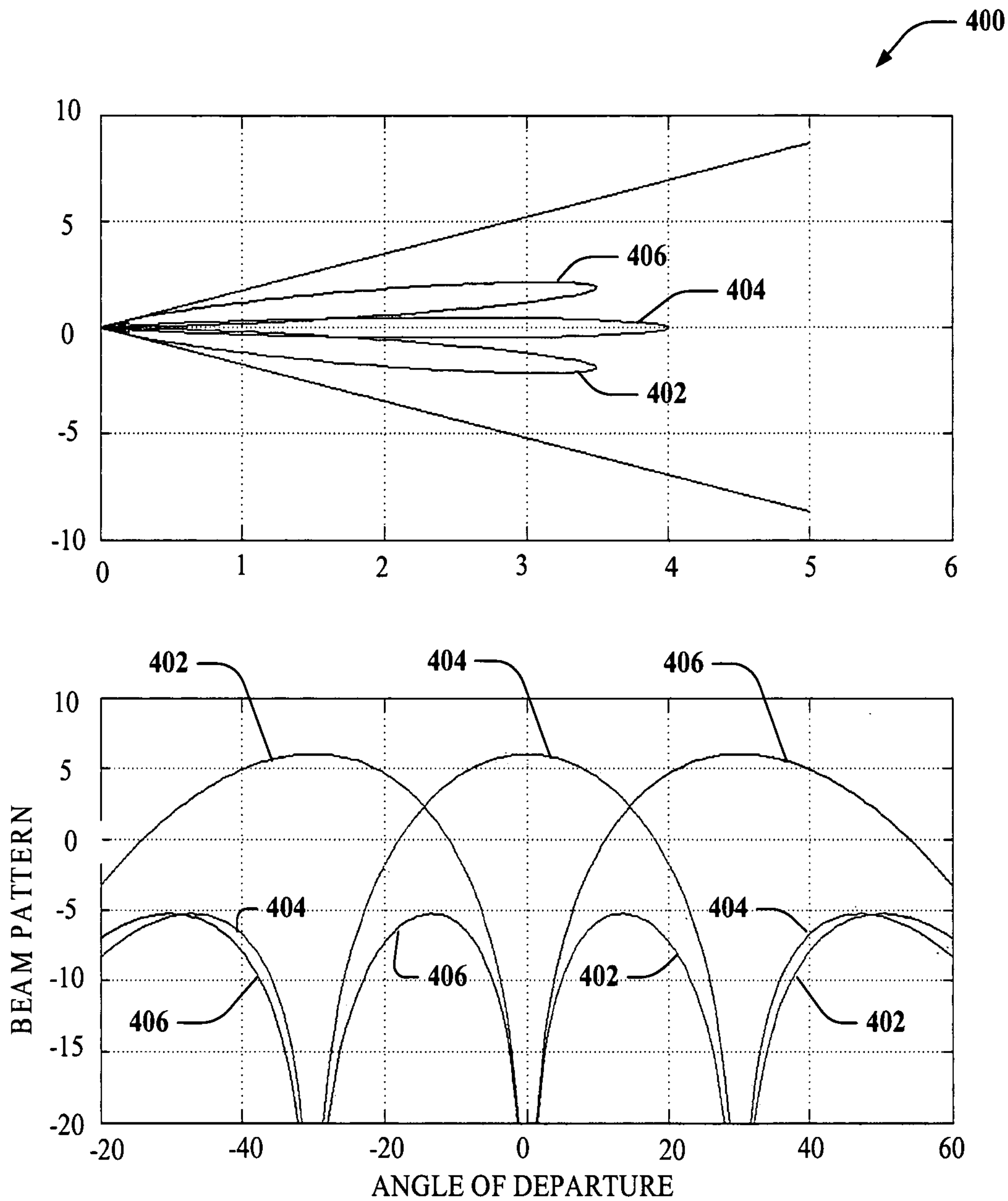


FIG. 3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10
5
0
-5
-10
0
1
2
3
4
5
6
406
404
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402
404
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BEAM PATTERN
10
5
0
-5
-10
-15
-20
-20
-40
-20
0
20
40
60
ANGLE OF DEPARTURE
404
406
406
402
404
402

FIG. 4

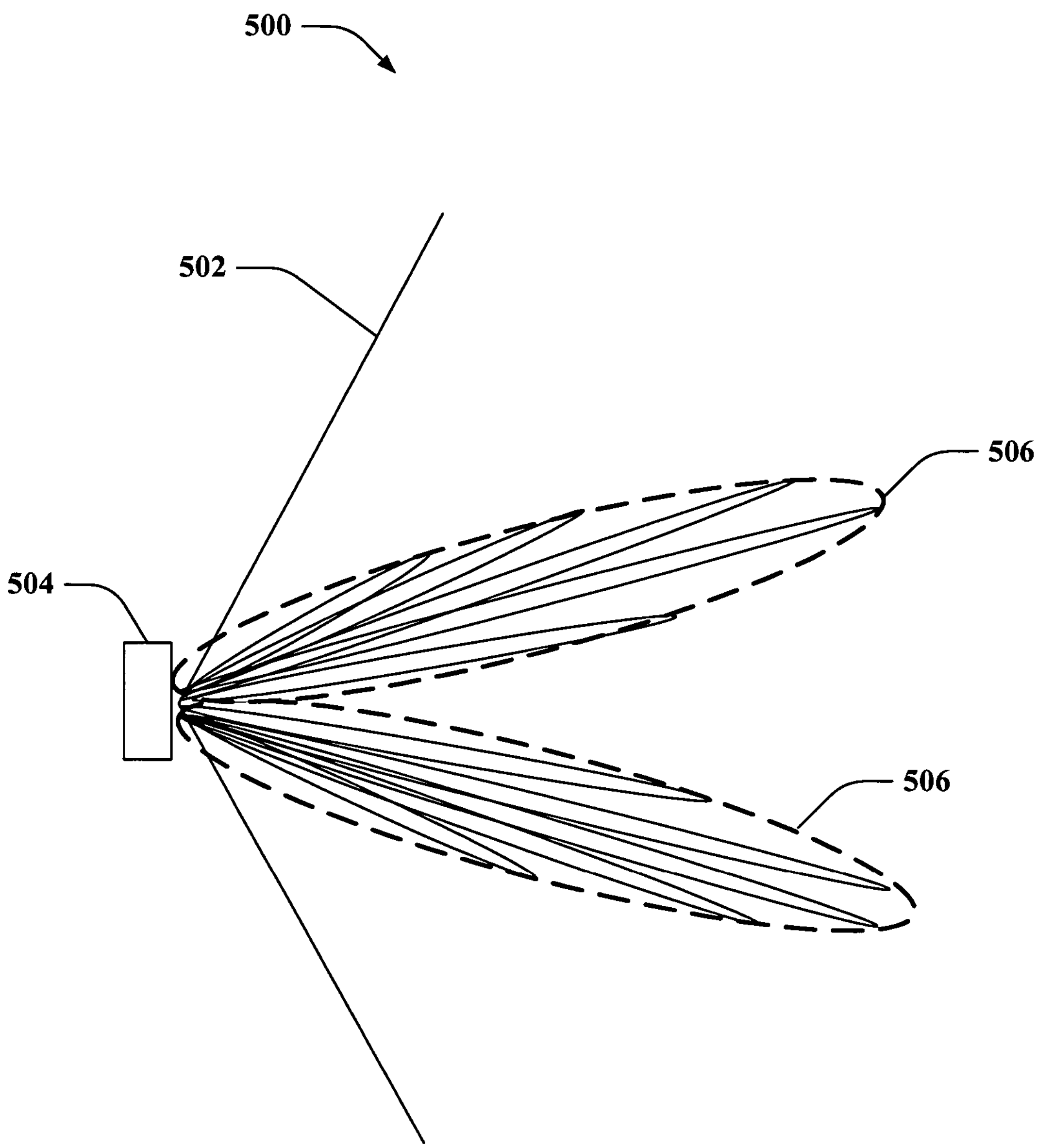


FIG. 5

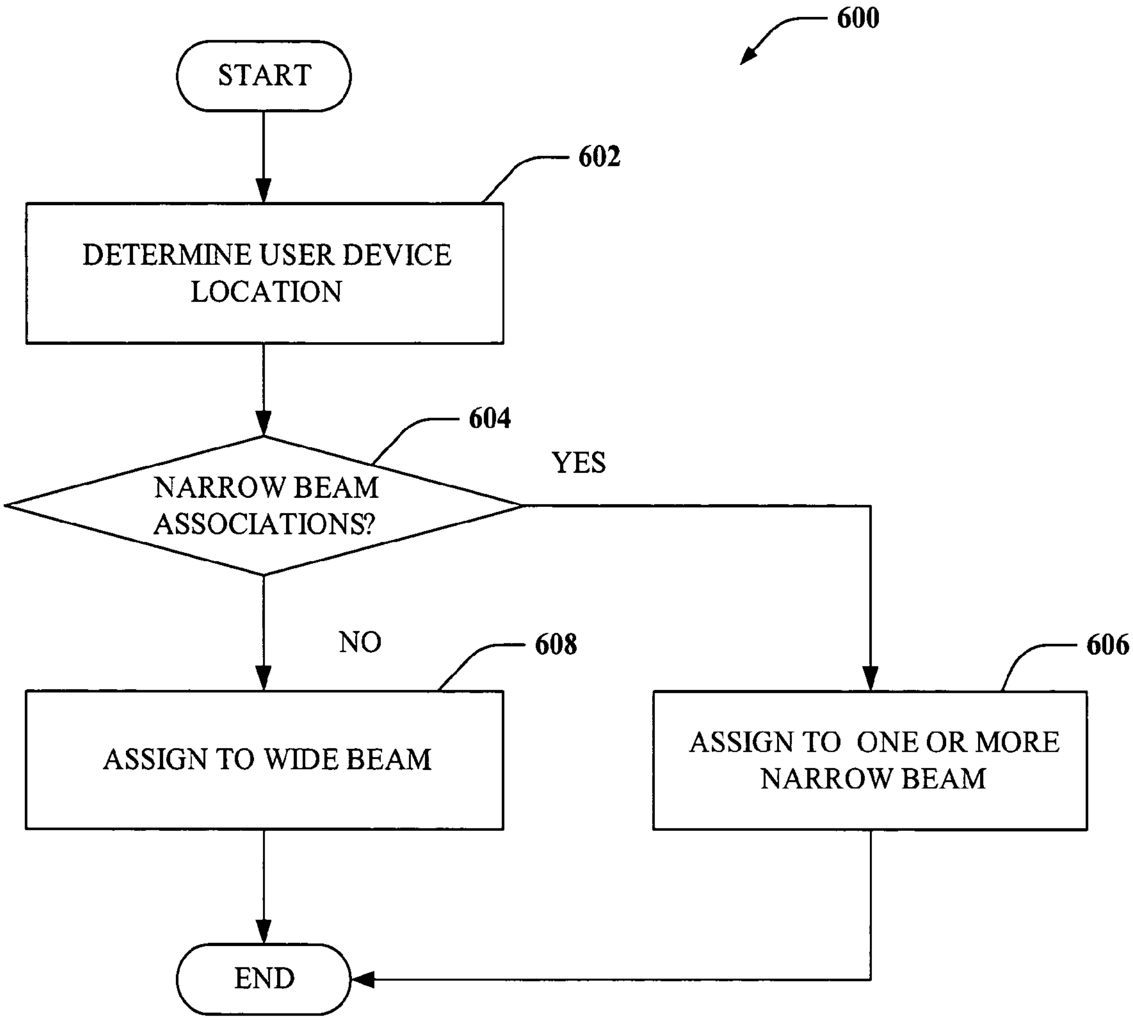

600
START
602
DETERMINE USER DEVICE LOCATION
604
YES
NARROW BEAM ASSOCIATIONS?
NO
608
606
ASSIGN TO WIDE BEAM
ASSIGN TO ONE OR MORE NARROW BEAM
END

FIG. 6

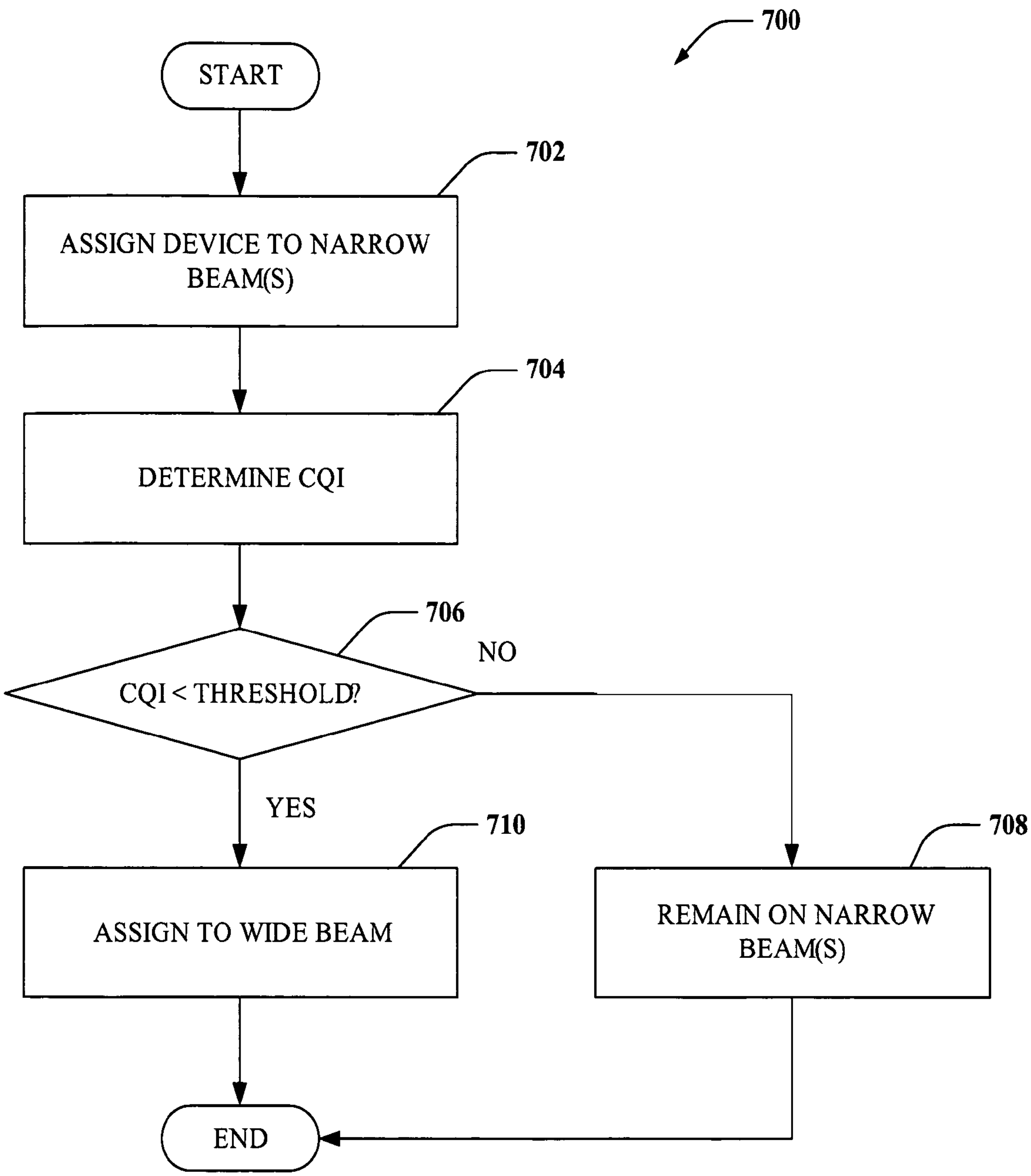
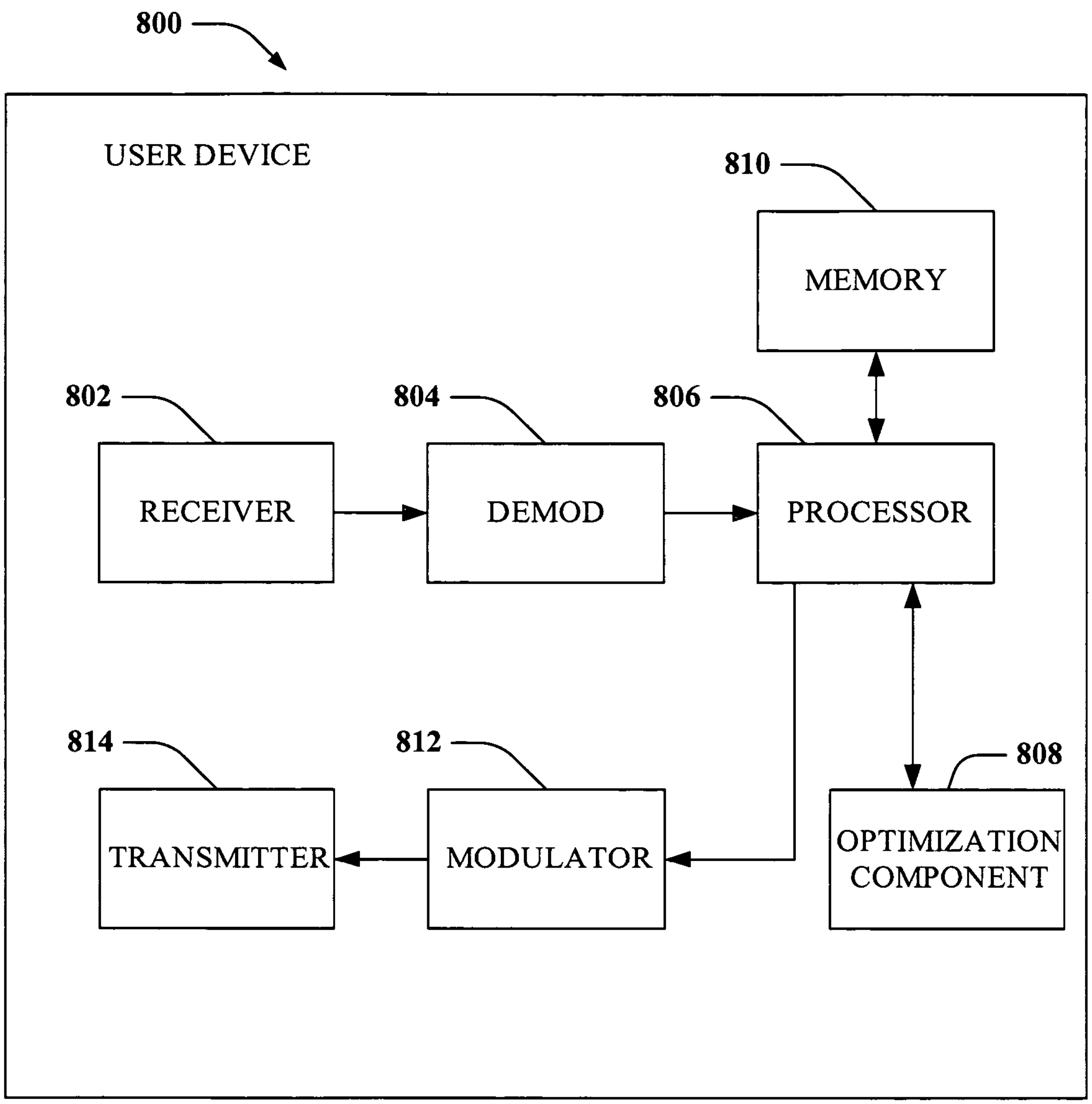

700
START
702
ASSIGN DEVICE TO NARROW BEAM(S)
704
DETERMINE CQI
706
NO
CQI < THRESHOLD?
YES
710
ASSIGN TO WIDE BEAM
708
REMAIN ON NARROW BEAM(S)
END

FIG. 7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USER DEVICE
810
MEMORY
802
RECEIVER
804
DEMOD
806
PROCESSOR
814
TRANSMITTER
812
MODULATOR
808
OPTIMIZATION COMPONENT

FIG. 8

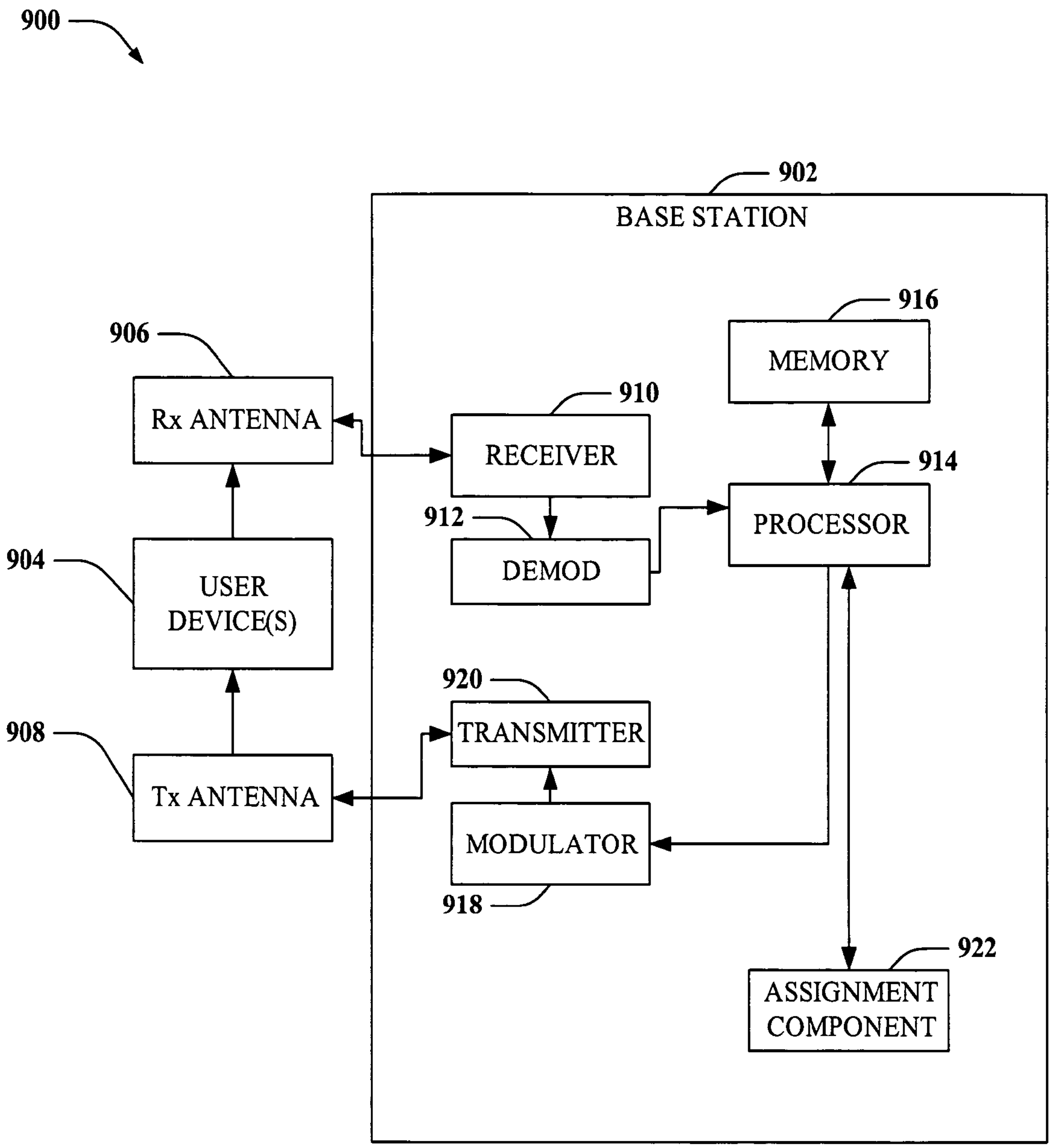
900
902
BASE STATION
916
MEMORY
906
Rx ANTENNA
910
RECEIVER
914
PROCESSOR
912
DEMOD
904
USER
DEVICE(S)
920
TRANSMITTER
908
Tx ANTENNA
MODULATOR
918
922
ASSIGNMENT
COMPONENT

FIG. 9

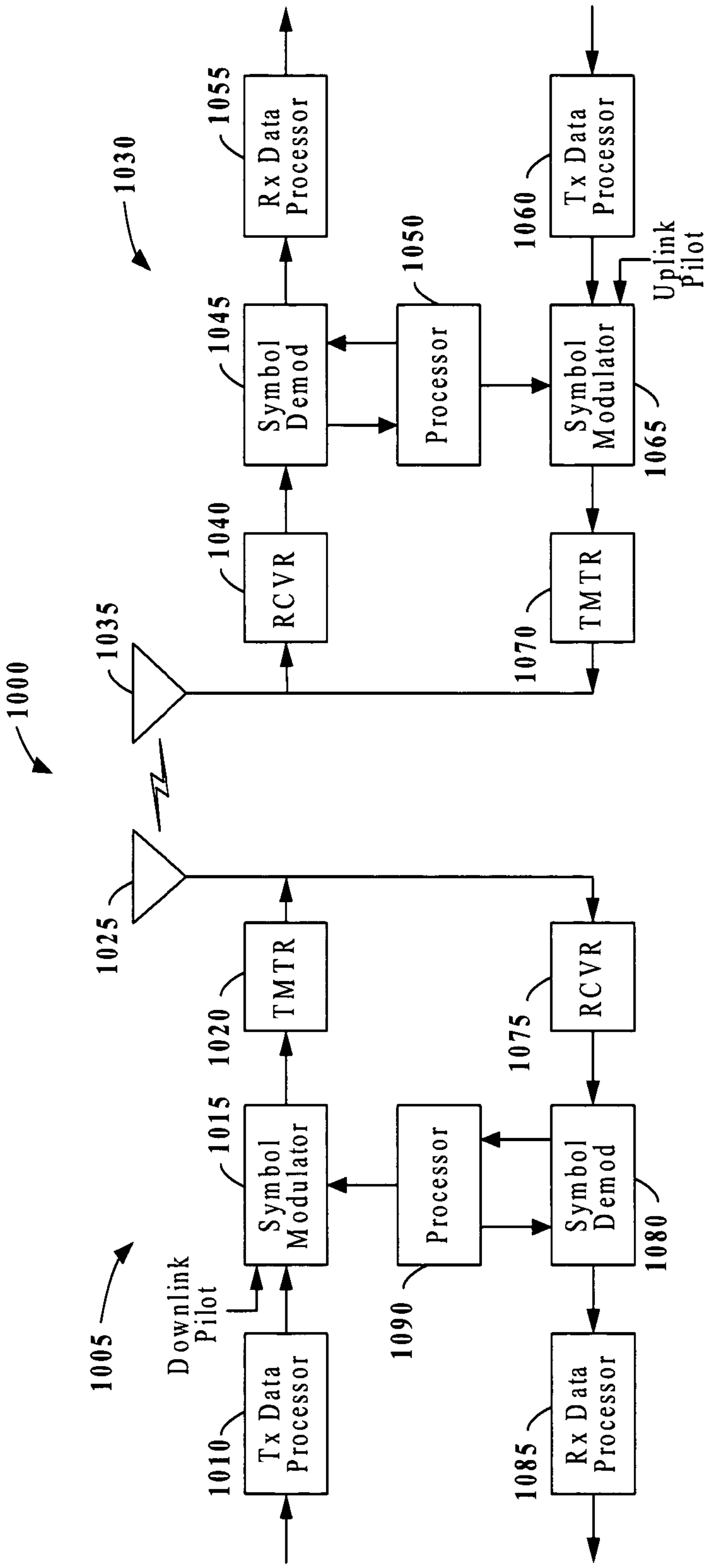
1000
1005
1010
Tx Data Processor
Downlink Pilot
1015
Symbol Modulator
1020
TMTR
1025
1035
1040
RCVR
1045
Symbol Demod
1050
Processor
1055
Rx Data Processor
1030
1060
Tx Data Processor
Uplink Pilot
1065
Symbol Modulator
1070
TMTR
1075
RCVR
1080
Symbol Demod
1085
Rx Data Processor
1090
Processor

FIG. 10

ADAPTIVE SECTORIZATION IN CELLULAR SYSTEMS

CROSS-REFERENCE TO RELATED APPLICATION

Claim of Priority Under 35 U.S.C. §119

The present Application for Patent claims priority to Provisional Application No. 60/691,716 filed Jun. 16, 2005, and assigned to the assignee hereof and hereby expressly incorporated by reference herein.

REFERENCE TO CO-PENDING APPLICATIONS FOR PATENT

The present Application for Patent is related to the following co-pending U.S. Patent Applications:

"CHANNEL QUALITY REPORTING FOR ADAPTIVE SECTORIZATION" having U.S. application Ser. No. 11/261,822, filed concurrently herewith, assigned to the assignee hereof, and expressly incorporated by reference herein.

"SDMA RESOURCE MANAGEMENT" having U.S. application Ser. No. 11/261,837, filed concurrently herewith, assigned to the assignee hereof, and expressly incorporated by reference herein.

BACKGROUND

I. Field

The following description relates generally to wireless communications, and, amongst other things, to flexible communication schemes for wireless communication systems.

II. Background

Wireless networking systems have become a prevalent means by which a majority of people worldwide has come to communicate. Wireless communication devices have become smaller and more powerful in order to meet consumer needs and to improve portability and convenience. Consumers have found many uses for wireless communication devices such as cellular telephones, personal digital assistants (PDAs) and the like, demanding reliable service and expanded areas of coverage.

Performance for a wireless communication system may be enhanced by using beamformed transmissions to communicate from the base station to the mobile devices. Multiple transmit antennas located at a base station can be used to form beamformed transmissions. Beamformed transmissions utilize "beams" that typically cover a narrower area than transmissions using a single transmit antenna. However, the signal to interference and noise ratio (SINR) is enhanced within the area covered by the beams. The portions of a sector not covered by a beam are referred to as a null region. Mobile devices located within the null region will have will have an extremely low SINR, resulting in reduced performance and possible loss of data. The communication system may use beam steering, in which beams are dynamically directed at particular user devices. During beam steering, beams are redirected as user devices change location.

A typical wireless communication network (e.g., employing frequency, time, and code division techniques) includes one or more base stations that provide a coverage area and one or more mobile (e.g., wireless) user devices that can transmit and receive data within the coverage area. A typical base station can simultaneously transmit multiple data streams for broadcast, multicast, and/or unicast services, wherein a data stream is a stream of data that can be of independent reception interest to a user device. A user device within the coverage area of that base station can be interested in receiving one, more than one or all the data streams carried by the composite stream. Likewise, a user device can transmit data to the base station or another user device. Such communication between base station and user device or between user devices can be degraded due to channel variations and/or interference power variations. For example, the aforementioned variations can affect base station scheduling, power control and/or rate prediction for one or more user devices.

Conventional network fixed beamformed transmissions result in null regions, reducing network reliability, robustness and coverage area. Thus, there exists a need in the art for a system and/or methodology for improved beamformed transmission coverage.

SUMMARY

The following presents a simplified summary of one or more embodiments in order to provide a basic understanding of such embodiments. This summary is not an extensive overview of all contemplated embodiments, and is intended to neither identify key or critical elements of all embodiments nor delineate the scope of any or all embodiments. Its sole purpose is to present some concepts of one or more embodiments in a simplified form as a prelude to the more detailed description that is presented later.

In accordance with one or more embodiments and corresponding disclosure thereof, various aspects are described in connection with enhancing performance in a wireless communication system using beamforming transmissions. According to one aspect, a set of transmit beams are defined that simultaneously provides for space division multiplexing, multiple-input multiple output (MIMO) transmission and opportunistic beamforming. The addition of a wide beam guarantees a minimum acceptable performance for all user devices.

To that end, a method for enhancing performance of a wireless communications environment is described herein, wherein the method can comprise determining channel information for a user, and assigning a user device to at least one of a predetermined at least one narrow beam or a wide beam. Additionally, the method can comprise assigning another user device during a same time period to at least some overlapping frequencies and a different one of the at least one predetermined at least one narrow beam and a wide beam as the user device. Moreover, the at least one predetermined narrow beam can comprise a cluster of narrow beams and another cluster of narrow beams, wherein the cluster and the another cluster do not overlap. The method can also comprise modifying the direction of the at least one predetermined at least one narrow beam based upon a pattern of communication of the user device or reassigning the user device from the predetermined at least one narrow beam to the wide beam based upon a channel quality indicator.

According to another aspect, a wireless communication apparatus can comprise a memory that stores information related to at least one predetermined at least one narrow beam and at least one wide beam and a processor, coupled to the memory, that assigns a user device to at least one of the predetermined at least one narrow beam and the wide beam. The processor can schedule communications for the user device based upon a spatial division multiplexing, MIMO or opportunistic beamforming scheduling technique. Additionally, the processor can generate the wide beam using a cyclic delay diversity scheme and transmit broadcast control transmissions over the wide beam. Moreover, the apparatus can comprise a first cluster of antennas, a first cluster of narrow beams employs the first cluster of antennas, and a second cluster of antennas, a second cluster of narrow beams employs the second cluster of antennas, wherein the first and second clusters of narrow beams do not overlap.

According to yet another aspect, an apparatus for enhancing system performance in a wireless communication environment comprises means for generating a predetermined at least one narrow beam, means for generating a wide beam, and means for assigning a user device to at least one of the predetermined at least one narrow beam and the wide beam. Additionally, the apparatus can comprise means for scheduling communications for the user device based upon a spatial division multiplexing, MIMO or opportunistic beamforming scheduling technique.

Yet another aspect relates to a computer-readable medium having stored thereon computer-executable instructions for generating a predetermined at least one narrow beam, generating a wide beam, and assigning a user device to at least one of the predetermined at least one narrow beam and the wide beam. Moreover, the medium can comprise instructions for scheduling communications for the user device based upon a spatial division multiplexing, MIMO or opportunistic beamforming scheduling technique.

Still another aspect relates to a processor that executes instructions for enhancing system performance in a multiple access wireless communication environment, the instructions comprising generating a predetermined at least one narrow beam, generating a wide beam, and assigning a user device to at least one of the predetermined at least one narrow beam and the wide beam. Additionally, the processor can execute instructions comprising scheduling communications for the user device based upon a spatial division multiplexing, MIMO or opportunistic beamforming scheduling technique.

A further aspect sets forth a mobile device that facilitates communicating over a wireless network, comprising a component that generates a predetermined at least one narrow beam, a component that generates a wide beam, and a component that assigns a user device to at least one of the predetermined at least one narrow beam and the wide beam.

To the accomplishment of the foregoing and related ends, the one or more embodiments comprise the features hereinafter fully described and particularly pointed out in the claims. The following description and the annexed drawings set forth in detail certain illustrative aspects of the one or more embodiments. These aspects are indicative, however, of but a few of the various ways in which the principles of various embodiments may be employed and the described embodiments are intended to include all such aspects and their equivalents.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** illustrates a beam pattern for a wireless communication system in accordance with various embodiments presented herein.

FIG. **2** is an illustration of a wireless communication system according to one or more embodiments presented herein.

FIG. **3** is an illustration of a wireless communication system according to one or more embodiments presented herein.

FIG. **4** is an illustration of a beam pattern for a wireless communication system in accordance with various embodiments presented herein.

FIG. **5** is an illustration of a beam pattern for a wireless communication system in accordance with various embodiments presented herein.

FIG. **6** illustrates a methodology for assigning a user device to a transmit beam in accordance with one or more aspects presented herein.

FIG. **7** illustrates a methodology for assigning a user device to a transmit beam in accordance with one or more aspects presented herein.

FIG. **8** is an illustration of a system that utilizes beamforming to increase system capacity in a wireless communication environment in accordance with various aspects.

FIG. **9** is an illustration of a system that utilizes beamforming to increase system capacity in a wireless communication environment in accordance with various aspects.

FIG. **10** is an illustration of a wireless communication environment that can be employed in conjunction with the various systems and methods described herein.

DETAILED DESCRIPTION

Various embodiments are now described with reference to the drawings, wherein like reference numerals are used to refer to like elements throughout. In the following description, for purposes of explanation, numerous specific details are set forth in order to provide a thorough understanding of one or more embodiments. It may be evident, however, that such embodiment(s) may be practiced without these specific details. In other instances, well-known structures and devices are shown in block diagram form in order to facilitate describing one or more embodiments.

Furthermore, various embodiments are described herein in connection with a user device. A user device can also be called a system, a subscriber unit, subscriber station, mobile station, mobile device, remote station, access point, base station, remote terminal, access terminal, user terminal, terminal, user agent, or user equipment. A user device can be a cellular telephone, a cordless telephone, a Session Initiation Protocol (SIP) phone, a wireless local loop (WLL) station, a PDA, a handheld communications or computing device having wireless connection capability, a smartphone, a satellite radio, a global position system, a laptop, or other processing device connected to a wireless modem.

Moreover, various aspects or features described herein may be implemented as a method, apparatus, or article of manufacture using standard programming and/or engineering techniques. The term "article of manufacture" as used herein is intended to encompass a computer program accessible from any computer-readable device, carrier, or media. For example, computer readable media can include but are not limited to magnetic storage devices (e.g., hard disk, floppy disk, magnetic strips . . .), optical disks (e.g., compact disk (CD), digital versatile disk (DVD) . . .), smart cards, and flash memory devices (e.g., card, stick, key drive . . .).

A wireless communication system can include one or more base stations in contact with one or more user devices. Each base station provides coverage for a plurality of sectors. In communication with a user device, the transmitting antennas of a base station can utilize beam-forming techniques in order to improve the signal-to-noise ratio of forward links for the different mobile devices. Forward link (or downlink) refers to the communication link from the base stations to mobile devices, and the reverse link (or uplink) refers to the communication link from mobile devices to the base stations. Additionally, a base station using beamforming to transmit to mobile devices scattered randomly through its coverage area causes less interference to mobile devices in neighboring cells/sectors than a base station transmitting through a single antenna to all mobile devices in its coverage area. Generally, beams generated by multiple transmit antennas are narrower than the coverage area of a single antenna. While user devices in the areas covered by beams experience an enhanced SINR, User devices within the null region experience a low SINR, possibly leading to loss of data. In general, user devices in the null region are worse off than if a single transmit antenna had been utilized to transmit performance.

While the disclosure discusses beamforming as a mode of operation, the disclosure and its contents may substantially be applied to precoded or beam-steered transmissions. This may be performed by, for example, utilizing fixed or predetermined matrices or vectors for which a user is scheduled.

FIG. **1** illustrates a beam pattern **100** for use in a wireless communication system in accordance with one or more embodiments presented herein. Base station transmit antennas can generate beams (e.g., a beam pattern) that can be employed to share time-frequency resources. The beam pattern can be adjusted from time to time, either periodically or based upon patterns of communication between the user devices and the base station. Multiple antennas at a base station **102** may assign a user on a first predetermined at least one narrow beam **104** or a second predetermined at least one narrow beam **106** for a sector **108**. Narrow beam, as used herein, indicates that there is a dominant vector, or vectors in the case of a preceding or beam steering, for the transmission. The number of beams shown has been limited to two for the sake of simplicity. However, additional fixed beams may be generated. Beams may be generally orthogonal as illustrated in FIG. **1**, or the coverage area of the beams may overlap. Users U**1** and U**2** are located within the coverage area of beams **106** and **104**, respectively. Consequently, users U**1** and U**2** experience an enhanced SINR, and/or other channel conditions similar to the benefits experienced by users in a beam-steering system. In contrast, users U**3** and U**4** will experience an extremely low SNR and/or other channel conditions since they are located within the null region of the beams **106** and **104**. In fact, the performance for users U**3** and U**4** may be worse than if a single transmit antenna had been utilized.

The problems inherent in the use of narrow beams may be mitigated by generating another beam pattern that is not directed or directed for the largest portion of the sector possible. In one or more embodiments, an additional wide beam **110** is generated. Wide beam **110** provides coverage for a substantial portion of the sector including the null region not covered by narrow beams **104** and **106**. Wide beam **110** provides users U**3** and U**4** with a guaranteed minimum level of performance.

Referring now to FIG. **2**, a wireless communication system **200** in accordance with various embodiments presented herein is illustrated. System **200** can comprise one or more base stations **202** in one or more sectors that receive, transmit, repeat, etc., wireless communication signals to each other and/or to one or more mobile devices **204**. Each base station **202** can comprise multiple transmitter chains and receiver chains, e.g. one for each transmit and receive antenna, each of which can in turn comprise a plurality of components associated with signal transmission and reception (e.g., processors, modulators, multiplexers, demodulators, demultiplexers, antennas, etc.). Mobile devices **204** can be, for example, cellular phones, smart phones, laptops, handheld communication devices, handheld computing devices, satellite radios, global positioning systems, PDAs, and/or any other suitable device for communicating over wireless system **200**.

Referring now to FIG. **3**, a multiple access wireless communication system **300** according to one or more embodiments is illustrated. A **3**-sector base station **302** includes multiple antenna groups, one including antennas **304** and **306**, another including antennas **308** and **310**, and a third including antennas **312** and **314**. According to the figure, only two antennas are shown for each antenna group, however, more or fewer antennas may be utilized for each antenna group. Typically, beamforming techniques require multiple transmit antennas to transmit beams. Mobile device **316** is in communication with antennas **312** and **314**, where antennas **312** and **314** transmit information to mobile device **316** over forward link **320** and receive information from mobile device **316** over reverse link **318**. Mobile device **322** is in communication with antennas **304** and **306**, where antennas **304** and **306** transmit information to mobile device **322** over forward link **326** and receive information from mobile device **322** over reverse link **324**.

Each group of antennas and/or the area in which they are designated to communicate may be referred to as a sector of base station **302**. In one or more embodiments, antenna groups each are designed to communicate to mobile devices in a sector of the areas covered by base station **302**. A base station may be a fixed station used for communicating with the terminals and may also be referred to as an access point, a Node B, or some other terminology. A mobile device may also be called a mobile station, user equipment (UE), a wireless communication device, terminal, access terminal, user device, or some other terminology.

Beamforming techniques can be used to provide fixed transmit directions in sectors or may be used in lieu of sectors. For example, beam patterns may provide multiple transmit directions in the sectors of a 3-sector base station, resulting in a virtual 6-sector base station. This ability to subdivide sectors results in increased system capacity.

Beamformed transmissions may be used with a number of different scheduling schemes, including space division multiplexing (SDM). SDM is a technique used in a multiple antenna communication system that utilizes the spatial dimensions to support additional user devices for data transmissions. A space division multiple access system (SDMA) system relies on spatial signatures associated with each user device to schedule data transmissions from or to multiple user devices and base stations. The spatial signature may be formed using the direction-of-arrival of the signal at the base station, the number of multipaths of the signal, and the attenuation of signal of each base station-mobile device pair or any other data that reflects the spatial relationship between the user device and base station. In a multiple antenna system, the spatial relationship between the base station and user device is determined based upon the signal received by the antennas at the base station. In this case, user device transmissions may be scheduled at the same time and on the same frequency on the beams and separated based upon a spatial signature. Through use of SDMA, disparate users can share time-frequency resources while not being associated with substantial cross talk.

Fixed beamforming patterns may also be used with MIMO and opportunistic beamforming scheduling techniques. In particular, user devices with well-conditioned matrix channels could be scheduled using MIMO. MIMO systems utilize multiple transmit and receive antennas to improve performance. Multiple data streams corresponding to a single user device are scheduled at the same time and frequency on multiple beams, thereby increasing the data rate. In opportunistic beamforming, also referred to as beam selection, the base station transmits to a single user device over a given set of frequencies and time using a beam. No other beams are used for transmission to any other user over those frequencies and at those times.

SDM, MIMO and opportunistic beamforming can be used with frequency division systems such as an orthogonal frequency division multiple access (OFDMA) system. An OFDMA system partitions the overall system bandwidth into multiple orthogonal subbands. These subbands are also referred to as tones, carriers, subcarriers, bins, and/or frequency channels. Each subband is associated with a subcarrier that can be modulated with data. An OFDMA system may use time and/or frequency division multiplexing to achieve orthogonality among multiple data transmissions for multiple user devices. Groups of user devices can be allocated separate subbands, and the data transmission for each user device may be sent on the subband(s) allocated to this user device. SDMA, MIMO and opportunistic beamforming can be implemented for user device allocated to different frequency regions.

In a beamformed transmission system, beamforming techniques can be used to provide fixed transmit directions in sectors or may be used in lieu of sectors. For example, beam patterns may provide multiple transmit directions in the sectors of a 3-sector base station, resulting in a virtual 6-sector base station. This ability to subdivide sectors results in increased system capacity. User devices served by a base station sector can indicate a preference for a given beam. The base station may schedule transmission with the user device on the given beam using SDM, MIMO, opportunistic beamforming or any other scheduling method. In addition, beamforming with a fixed beam pattern allows a base station to utilize SDM, MIMO and opportunistic beamforming scheduling techniques simultaneously. For example, spatially orthogonal user devices may be scheduled using SDM, user devices with well-conditioned matrix channels could be scheduled using MIMO and additional users could be scheduled using opportunistic beamforming.

Systems utilizing fixed, narrow beams and the techniques discussed above can provide for enhanced throughput in a wireless communications environment. However, such systems lack robustness due to null regions.

Looking once again at FIG. **1**, user devices U**1** and U**2** are spatially orthogonal with disparate spatial signatures. Consequently, user device U**1** and U**2** would experience enhanced SINR using either SDM or opportunistic beamforming schemes. In contrast, user devices U**3** and U**4** will likely experience degraded SINR due to their location. Because both U**3** and U**4** are located within the null region, they will likely experience worse performance than if the system utilized a single transmit antenna.

Limited coverage areas of narrow beams may impact user device reliability and robustness. In general, user devices are designed to be mobile. Consequently, a user device may begin a transmission through utilization of a beam and may thereafter enter into a null region during transmission. Transmission within null regions may cause loss of data and decreased reliability. In addition, user devices may simply select the wrong beam. For example, user device U**1** may be desirably associated with a second beam **106**. However, if user device U**1** incorrectly elects transmissions over first beam **104** or if the user device U**1** is incapable of electing a beam and is assigned to first beam **104** by the base station, the user device will experience the same performance as if the user device was located in the null region. Therefore, one or more user devices in a null region or otherwise having poor performance may be assigned to the wide beam. In addition, broadcast and control transmissions may be assigned to the wide beam.

The addition of a wide beam can ensure a minimum level of performance. The wide beam can be created using a transmission scheme that emulates a single antenna. For example, the wide beam may be generated using a cyclic delay diversity scheme. In general, the wide beam will have a low SINR gain compared to the narrow beams, but a significantly wider area of coverage than the narrow beams. User device can elect to be assigned to the wide beam. Consequently, the worst performance for any user device is limited to that of a single antenna transmission. Moreover, many user devices will experience enhanced performance in the narrow beam coverage areas. The base station can schedule user devices located in the narrow beam coverage areas using SDM, MIMO or beam selection methods or any combination thereof. The addition of the wide beam provides a guaranteed minimum level of robustness.

In addition, the system may utilize the wide beam to support broadcast control channels. Because the wide beam can be undirected or directed at a majority of the sector, the wide beam can be used to transmit to most or all of the user devices served by the sector simultaneously. Consequently, the base station does not have to transmit separate control transmissions for each narrow beam. A user device can be assigned to at least one of the narrow beam and the wide beam based upon type of data that is to be transmitted to the user device.

Referring now to FIG. **4**, a beam pattern **400** utilizing multiple beams **402**, **404** and **406** is illustrated. In one or more alternate embodiments, a base station can generate multiple narrow beams **402**, **404** and **406** to effectively communicate with mobile stations in a sector, in addition to or instead of a wide beam. Use of multiple narrow beams, may not adequately mitigate when the user device selects the wrong beam. However, as long as the correct beam is selected, user devices in the sector will experience enhanced performance. Beams **402**, **404** and **406** can be either orthogonal or overlapping. As shown in FIG. **4**, beams **402**, **404** and **406** including their side lobes can be directed to effectively cover a sector.

In one or more embodiment, separate, fixed beams can be content specific. Fixed beams may be associated with specific, predictable directions for geographic areas or locations. Consequently, content specific to a particular location can be transmitted to user devices within the coverage area of a fixed beam associated with that location. For example, a mall can include a wireless communication system. Content specific to a first store at a first location in the mall may be transmitted using a first beam and content specific to a second store at a second location may be transmitted using a second beam. Consequently, user devices located at the first and second stores will receive transmissions specific to the store in which they are located. General mall information can be transmitted using a wide beam with a coverage area including the entire mall. Alternatively, narrow beams may be used to provide improved performance. For example, the wide beam may be used for general mall traffic, while a narrow beam may be directed at a first store having critical communication needs.

In one or more embodiments, beams are formed using a set of weights, that alter the phase, amplitude, or phase and amplitude of a particular transmission symbol or sample. These weights can be stored in a lookup table in memory. Beams can be updated by modifying the weights stored in the lookup table.

Referring now to FIG. **5**, a beam pattern **500** for a sector **502** for a wireless communication system in accordance with various embodiments is illustrated. In general, SDMA, pre-coding and beamforming techniques are implemented using correlated antennas. However, uncorrelated antennas are preferable for MIMO transmissions and for receive antennas and in one or more embodiments, the same antennas may be utilized for both transmission and reception. To provide for MIMO, SDM and pre-coding simultaneously, a base station **504** can include two or more clusters of antennas. Antennas within each cluster are closely spaced. However, a larger distance separates the clusters of antennas. For example, separation of antennas within the cluster can be ½λ, while separation between clusters can be 5λ. This antenna configuration provides the diversity necessary for efficient MIMO and at the same time is sufficiently correlated for SDM, precoding, etc. The antenna configuration is capable of producing the beam pattern illustrated in FIG. **5**. Here, clusters of beams **506** generate envelopes with the same effective beam pattern as the first and second beam shown in FIG. **1**. The beam pattern illustrated in FIG. **5** can be used to support MIMO and SDMA simultaneously, thereby increasing the capacity of the system. It should be noted that in the case of preceding or beam steering, the directions show may be one direction or the dominant direction of the beam. The one or more narrow beams can each include a cluster of narrow beams and another cluster of narrow beams, wherein the clusters of narrow beams do not overlap.

Referring to FIGS. **6**-**7**, methodologies relating to increasing capacity in wireless communication systems are illustrated. For example, methodologies can relate to using beamforming in an SDMA environment, in an FDMA environment, an OFDMA environment, a CDMA environment, a WCDMA environment, a TDMA environment or any other suitable wireless environment. While, for purposes of simplicity of explanation, the methodologies are shown and described as a series of acts, it is to be understood and appreciated that the methodologies are not limited by the order of acts, as some acts may, in accordance with one or more embodiments, occur in different orders and/or concurrently with other acts from that shown and described herein. For example, those skilled in the art will understand and appreciate that a methodology could alternatively be represented as a series of interrelated states or events, such as in a state diagram. Moreover, not all illustrated acts may be utilized to implement a methodology in accordance with one or more embodiments.

Referring now to FIG. **6**, a methodology **600** for assigning a user device to a beam in a wireless communication environment in accordance with one or more embodiments presented herein is illustrated. This methodology is described with respect to a system using one or more narrow beams in combination with a wide beam, wherein time-frequency resources can be shared between one or more of a set of narrow beams and the wide beam. At **602**, the spatial relationship between the user device and the base station is determined. The spatial relationship can be determined based upon the spatial signal of the base station-user device pair. Alternatively, the user device can include a global positioning system (GPS) capable of determining the location of the user device. At **604**, it is determined whether the user device is to be associated with at least one narrow beam transmitted by the base station. If yes, the user device is assigned to the at least one narrow beam at **606**. This assignment can be based upon information transmitted prior to the assignment, wherein the information is indicative of a predetermined at least one narrow beam and the wide beam. For instance, the information can comprise entries from a codebook. Moreover, the information can be quantized prior to transmitting such information. If no, the user device is assigned to the wide beam at **608**. User devices can request specific beams or, alternatively, the base station can determine which user devices to assign to specific beams. In another example, a disparate user device can be to non-overlapping frequencies outside of the narrow beam or wide beam.

Referring now to FIG. **7**, a methodology **700** for assigning a user device to a beam in a wireless communication environment in accordance with one or more embodiments presented herein is illustrated. At **702**, a user device is assigned to at least one narrow beam. The channel quality indicator (CQI) (or other suitable channel quality information) for the user device is determined at **704**. At **706**, it is determined whether the CQI for user device is below a predetermined threshold. It should be noted that this threshold is determined by the CQI of the wide beam, or CQIs depending on the number of users assigned to the wide beam. As such, this threshold may vary over time as the CQI(s) of the user(s) assigned to the wide beam vary over time. Alternatively, a fixed threshold may also be utilized.

If no, the user device beam assignment remains unchanged at **708**. If yes, the user device is assigned to the wide beam at **710**. Alternatively, the quality of service (QoS) may be monitored to determine whether to switch a user device to the wide beam. The QoS, CQI, other channel information, or combinations thereof may be monitored just after the initial assignment or may be monitored periodically.

In general, user devices are capable of relocating or being relocated during voice or data transmission, thereby changing the spatial relationship between user device and base station. Accordingly, a directed narrow beam may not be an optimal mode for sending and receiving communications. Therefore, user devices may be reassigned as they move through the sector. The velocity of the user device can be monitored to determine whether the user device is moving in and out of the narrow beams so quickly that superior performance can be achieved by assigning the user device to the wide beam. In one or more embodiments, the user device can include an accelerometer. When the accelerometer indicates that the user device is moving quickly and therefore likely to move in and out of the narrow beam coverage area rapidly, the user device may be assigned to the wide beam, thereby avoiding repeated reassignment of the user device to multiple narrow beams.

It will be appreciated that, in accordance with one or more embodiments described herein, inferences can be made regarding transmission formats, frequencies, etc. As used herein, the term to "infer" or "inference" refers generally to the process of reasoning about or inferring states of the system, environment, and/or user from a set of observations as captured via events and/or data. Inference can be employed to identify a specific context or action, or can generate a probability distribution over states, for example. The inference can be probabilistic—that is, the computation of a probability distribution over states of interest based on a consideration of data and events. Inference can also refer to techniques employed for composing higher-level events from a set of events and/or data. Such inference results in the construction of new events or actions from a set of observed events and/or stored event data, whether or not the events are correlated in close temporal proximity, and whether the events and data come from one or several event and data sources.

According to an example, one or methods presented above can include making inferences regarding a pattern of beams to allocate to a particular sector based upon the quality of service required in the sector. For example, it can be determined that high quality service is required in an area due to the critical nature of the communications to user devices in that area or simply due to the large number of user devices or customers in an area.

According to another example, inferences can be made relating to a beam pattern to employ during various times of the day, week, etc., such as peak hours and the like. It will be appreciated that the foregoing examples are illustrative in nature and are not intended to limit the number of inferences that can be made or the manner in which such inferences are made in conjunction with the various embodiments and/or methods described herein.

FIG. **8** is an illustration of a system **800** that facilitates beam forming in a wireless communication environment to increase system capacity limits in accordance with one or more embodiments set forth herein. System **800** can reside in a base station and/or in a user device, as will be appreciated by one skilled in the art. System **800** comprises a receiver **802** that receives a signal and from, for instance one or more receive antennas, and performs typical actions thereon (e.g., filters, amplifies, downconverts, etc.) the received signal and digitizes the conditioned signal to obtain samples. A demodulator **804** can demodulate and provide received pilot symbols to a processor **806** for channel estimation.

Processor **806** can be a processor dedicated to analyzing information received by receiver component **802** and/or generating information for transmission by a transmitter **814**. Processor **806** can be a processor that controls one or more components of user device **800**, and/or a processor that analyzes information received by receiver **802**, generates information for transmission by a transmitter **814**, and controls one or more components of user device **800**. User device **800** can include an optimization component **808** that coordinates beam assignments. Optimization component **808** may be incorporated into the processor **806**. It is to be appreciated that optimization component **808** can include optimization code that performs utility based analysis in connection with assigning user devices to beams. The optimization code can utilize artificial intelligence based methods in connection with performing inference and/or probabilistic determinations and/or statistical-based determinations in connection with optimizing user device beam assignments.

User device **800** can additionally comprise memory **810** that is operatively coupled to processor **806** and that stores information related to beam pattern information, lookup tables comprising information related thereto, and any other suitable information related to beamforming as described herein. Memory **810** can additionally store protocols associated with generating lookup tables, etc., such that user device **800** can employ stored protocols and/or algorithms to increase system capacity. It will be appreciated that the data store (e.g., memories) components described herein can be either volatile memory or nonvolatile memory, or can include both volatile and nonvolatile memory. By way of illustration, and not limitation, nonvolatile memory can include read only memory (ROM), programmable ROM (PROM), electrically programmable ROM (EPROM), electrically erasable ROM (EEPROM), or flash memory. Volatile memory can include random access memory (RAM), which acts as external cache memory. By way of illustration and not limitation, RAM is available in many forms such as synchronous RAM (SRAM), dynamic RAM (DRAM), synchronous DRAM (SDRAM), double data rate SDRAM (DDR SDRAM), enhanced SDRAM (ESDRAM), Synchlink DRAM (SLDRAM), and direct Rambus RAM (DRRAM). The memory **810** of the subject systems and methods is intended to comprise, without being limited to, these and any other suitable types of memory. The processor **806** is connected to a symbol modulator **812** and transmitter **814** that transmits the modulated signal.

FIG. **9** is an illustration of a system **900** that facilitates increasing system capacity in a communication environment in accordance with various embodiments. System **900** comprises a base station **902** with a receiver **910** that receives signal(s) from one or more user devices **904** via one or more receive antennas **906**, and transmits to the one or more user devices **904** through a plurality of transmit antennas **908**. In one or more embodiments, receive antennas **906** and transmit antennas **908** can be implemented using a single set of antennas. Receiver **910** can receive information from receive antennas **906** and is operatively associated with a demodulator **912** that demodulates received information. Receiver **910** can be, for example, a Rake receiver (e.g., a technique that individually processes multi-path signal components using a plurality of baseband correlators, . . .), an MMSE-based receiver, or some other suitable receiver for separating out user devices assigned thereto, as will be appreciated by one skilled in the art. According to various aspects, multiple receivers can be employed (e.g., one per receive antenna), and such receivers can communicate with each other to provide improved estimates of user data. Demodulated symbols are analyzed by a processor **914** that is similar to the processor described above with regard to FIG. **8**, and is coupled to a memory **916** that stores information related to user device assignments, lookup tables related thereto and the like. Receiver output for each antenna can be jointly processed by receiver **910** and/or processor **914**. A modulator **918** can multiplex the signal for transmission by a transmitter **920** through transmit antennas **908** to user devices **904**.

Base station **902** further comprises an assignment component **922**, which can be a processor distinct from or integral to processor **914**, and which can evaluate a pool of all user devices in a sector served by base station **904** and can assign user devices to beams based at least in part upon the location of the individual user devices.

FIG. **10** shows an exemplary wireless communication system **1000**. The wireless communication system **1000** depicts one base station and one user device for sake of brevity. However, it is to be appreciated that the system can include more than one base station and/or more than one user device, wherein additional base stations and/or user devices can be substantially similar or different from the exemplary base station and user device described below. In addition, it is to be appreciated that the base station and/or the user device can employ the systems (FIGS. **8**-**9**) and/or methods (FIGS. **6**-**7**) described herein to facilitate wireless communication there between.

Referring now to FIG. **10**, on a downlink, at access point **1005**, a transmit (TX) data processor **1010** receives, formats, codes, interleaves, and modulates (or symbol maps) traffic data and provides modulation symbols ("data symbols"). A symbol modulator **1015** receives and processes the data symbols and pilot symbols and provides a stream of symbols. Symbol modulator **1015** multiplexes data and pilot symbols and provides them to a transmitter unit (TMTR) **1020**. Each transmit symbol may be a data symbol, a pilot symbol, or a signal value of zero. The pilot symbols may be sent continuously in each symbol period. The pilot symbols can be frequency division multiplexed (FDM), orthogonal frequency division multiplexed (OFDM), time division multiplexed (TDM), frequency division multiplexed (FDM), or code division multiplexed (CDM).

TMTR **1020** receives and converts the stream of symbols into one or more analog signals and further conditions (e.g., amplifies, filters, and frequency upconverts) the analog signals to generate a downlink signal suitable for transmission over the wireless channel. The downlink signal is then transmitted through an antenna **1025** to the user devices. At user device **1030**, an antenna **1035** receives the downlink signal and provides a received signal to a receiver unit (RCVR) **1040**. Receiver unit **1040** conditions (e.g., filters, amplifies, and frequency downconverts) the received signal and digitizes the conditioned signal to obtain samples. A symbol demodulator **1045** demodulates and provides received pilot symbols to a processor **1050** for channel estimation. Symbol demodulator **1045** further receives a frequency response estimate for the downlink from processor **1050**, performs data demodulation on the received data symbols to obtain data symbol estimates (which are estimates of the transmitted data symbols), and provides the data symbol estimates to an RX data processor **1055**, which demodulates (i.e., symbol demaps), deinterleaves, and decodes the data symbol estimates to recover the transmitted traffic data. The processing by symbol demodulator **1045** and RX data processor **1055** is complementary to the processing by symbol modulator **1015** and TX data processor **1010**, respectively, at access point **1005**.

On the uplink, a TX data processor **1060** processes traffic data and provides data symbols. A symbol modulator **1065** receives and multiplexes the data symbols with pilot symbols, performs modulation, and provides a stream of symbols. A transmitter unit **1070** then receives and processes the stream of symbols to generate an uplink signal, which is transmitted by the antenna **1035** to the access point **1005**.

At access point **1005**, the uplink signal from user device **1030** is received by the antenna **1025** and processed by a receiver unit **1075** to obtain samples. A symbol demodulator **1080** then processes the samples and provides received pilot symbols and data symbol estimates for the uplink. An RX data processor **1085** processes the data symbol estimates to recover the traffic data transmitted by user device **1030**. A processor **1090** performs channel estimation for each active user device transmitting on the uplink. Multiple user devices may transmit pilot concurrently on the uplink on their respective assigned sets of pilot subbands, where the pilot subband sets may be interlaced.

Processors **1090** and **1050** direct (e.g., control, coordinate, manage, etc.) operation at access point **1005** and user device **1030**, respectively. Respective processors **1090** and **1050** can be associated with memory units (not shown) that store program codes and data. Processors **1090** and **1050** can also perform computations to derive frequency and impulse response estimates for the uplink and downlink, respectively.

For a multiple-access system (e.g., FDMA, OFDMA, CDMA, TDMA, SDMA, etc.), multiple user devices can transmit concurrently on the uplink.

For such a system, the pilot subbands may be shared among different user devices. The channel estimation techniques may be used in cases where the pilot subbands for each user device span the entire operating band (possibly except for the band edges). Such a pilot subband structure would be desirable to obtain frequency diversity for each user device. The techniques described herein may be implemented by various means. For example, these techniques may be implemented in hardware, software, or a combination thereof. For a hardware implementation, the processing units used for channel estimation may be implemented within one or more application specific integrated circuits (ASICs), digital signal processors (DSPs), digital signal processing devices (DSPDs), programmable logic devices (PLDs), field programmable gate arrays (FPGAs), processors, controllers, micro-controllers, microprocessors, other electronic units designed to perform the functions described herein, or a combination thereof. With software, implementation can be through modules (e.g., procedures, functions, and so on) that perform the functions described herein. The software codes may be stored in memory unit and executed by the processors **1090** and **1050**.

For a software implementation, the techniques described herein may be implemented with modules (e.g., procedures, functions, and so on) that perform the functions described herein. The software codes may be stored in memory units and executed by processors. The memory unit may be implemented within the processor or external to the processor, in which case it can be communicatively coupled to the processor via various means as is known in the art.

What has been described above includes examples of one or more embodiments. It is, of course, not possible to describe every conceivable combination of components or methodologies for purposes of describing the aforementioned embodiments, but one of ordinary skill in the art may recognize that many further combinations and permutations of various embodiments are possible. Accordingly, the described embodiments are intended to embrace all such alterations, modifications and variations that fall within the spirit and scope of the appended claims. Furthermore, to the extent that the term "includes" is used in either the detailed description or the claims, such term is intended to be inclusive in a manner similar to the term "comprising" as "comprising" is interpreted when employed as a transitional word in a claim.

What is claimed is:

1. A method for enhancing performance for a wireless communication environment, comprising:

determining channel information for user devices;

assigning the user devices to at least one beam from a predetermined set of beams, the set of beams comprising at least one narrow beam and a wide beam, wherein assigning the user devices to the at least one narrow beam comprises scheduling a first user device using a spatial division multiplexing (SDM) scheduling technique and scheduling a second user device using a multiple-in multiple-out (MIMO) scheduling technique, and wherein the at least one narrow beam and the wide beam are separate beams,

reassigning at least one user device from a narrow beam to the wide beam if channel quality information is lower than a threshold value,

wherein the at least one narrow beam comprises a first cluster of narrow beams having a dominant direction and a second cluster of narrow beams having a dominant direction, wherein the dominant direction of the first cluster is different from the dominant direction of the second cluster; and

scheduling the first and second user devices simultaneously, using said SDM scheduling technique and said MIMO scheduling technique, by employing the first cluster of narrow beams and the second cluster of narrow beams.

2. The method of claim **1**, further comprising assigning another user device during a same time period to at least some overlapping frequencies and a beam that is not part of the predetermined set of beams.

3. The method of claim **1**, further comprising generating the wide beam using a cyclic delay diversity scheme.

4. The method of claim **1**, further comprising assigning, to the wide beam, broadcast control transmissions for transmission to one or more of the user devices.

5. The method of claim **1**, further comprising modifying the direction of the at least one narrow beam based upon a pattern of communication of the user devices.

6. The method of claim **1**, wherein the channel quality information comprises a channel quality indicator.

7. The method of claim **1**, wherein the channel quality information is a signal to interference and noise ratio.

8. The method of claim **1**, further comprising assigning a user device to the wide beam based upon a determined velocity of the user device, wherein the velocity is determined by an accelerometer in the user device.

9. The method of claim 1, wherein assigning the user devices comprises assigning a user device based at least in part upon a request by the user device indicating at least one beam from the predetermined set of beams.

10. The method of claim 1, wherein assigning the user devices comprises assigning a user device based at least in part upon a quality of service indicated for the user device.

11. The method of claim 1, wherein assigning the user devices comprises assigning a user device based at least in part upon a type of data to be transmitted to the user device.

12. The method of claim 1, wherein the at least one narrow beam comprises a first cluster of narrow beams and a second cluster of narrow beams, wherein at least some of the first cluster and the second cluster overlap.

13. The method of claim 1, further comprising assigning another user device during a same time period to non-overlapping frequencies.

14. The method of claim 1, further comprising, prior to assigning, transmitting a transmission containing information indicative of the at least one beam.

15. The method of claim 14, wherein the information comprises entries from a codebook.

16. The method of claim 14, further comprising quantizing the information indicative prior to transmitting.

17. A wireless communication apparatus, comprising:

a memory that stores information related to a predetermined set of beams, the set of beams comprising at least one narrow beam and a wide beam, wherein the at least one narrow beam and the wide beam are separate beams;

a processor, coupled to the memory, that assigns user devices to at least one beam from the predetermined set of beams, wherein assigning the user devices to the at least one narrow beam comprises scheduling a first user device using a spatial division multiplexing (SDM) scheduling technique and scheduling a second user device using a multiple-in multiple-out (MIMO) scheduling technique,

wherein the processor reassigns at least one user device from a narrow beam to the wide beam if channel quality information is lower than a threshold value;

a first cluster of antennas, wherein a first cluster of narrow beams employs the first cluster of antennas; and

a second cluster of antennas, wherein a second cluster of narrow beams utilizes the second cluster of antennas, wherein a first dominant direction of the first cluster is different from a second dominant direction of the second cluster, and wherein the first and second user devices are scheduled simultaneously, using said SDM scheduling technique and said MIMO scheduling technique, by employing the first cluster of narrow beams and the second cluster of narrow beams.

18. The apparatus of claim 17, wherein the processor schedules communications for the user devices based upon a spatial division multiplexing, multiple input multiple output (MIMO) or opportunistic beamforming scheduling technique.

19. The apparatus of claim 17, wherein the processor generates the wide beam using a cyclic delay diversity scheme.

20. The apparatus of claim 17, wherein the processor transmits broadcast control transmissions over the wide beam.

21. The apparatus of claim 17, wherein the processor modifies the direction of the at least one narrow beam based upon a pattern of communication of the user devices.

22. The apparatus of claim 17, wherein the channel quality information comprises a channel quality indicator.

23. The apparatus of claim 22, the channel quality indicator is a signal to interference and noise ratio.

24. The apparatus of claim 17, wherein the processor assigns a user device to the wide beam based upon a velocity of the user device, wherein the velocity is determined by an accelerometer in the user device.

25. The apparatus of claim 17, wherein a user device indicates a preference for the at least one beam from the predetermined set of beams in a request.

26. An apparatus for enhancing performance for a wireless communication environment, comprising:

means for generating at least one narrow beam;

means for generating a wide beam, wherein the at least one narrow beam and the wide beam are separate beams;

means for assigning user devices to at least one beam from a predetermined set of beams, the set of beams comprising the at least one narrow beam and the wide beam, wherein assigning the user devices to the at least one narrow beam comprises scheduling a first user device using a spatial division multiplexing (SDM) scheduling technique and scheduling a second user device using a multiple-in multiple-out (MIMO) scheduling technique,

means for reassigning at least one user device from a narrow beam to the wide beam if channel quality information is lower than a threshold value;

a first cluster of antennas, wherein a first cluster of narrow beams employs the first cluster of antennas; and

a second cluster of antennas, wherein a second cluster of narrow beams utilizes the second cluster of antennas, wherein a first dominant direction of the first cluster is different from a second dominant direction of the second cluster; and wherein the first and second user devices are scheduled simultaneously, using said SDM scheduling technique and said MIMO scheduling technique, by employing the first cluster of narrow beams and the second cluster of narrow beams.

27. The apparatus of claim 26, further comprising means for scheduling communications for the user devices based upon a spatial division multiplexing, multiple input multiple output (MIMO) or opportunistic beamforming scheduling technique.

28. The apparatus of claim 26, further comprising means for modifying the direction of the at least one narrow beam based upon a pattern of communication of the user devices.

29. The apparatus of claim 26, wherein the channel quality information comprises a channel quality indicator.

30. The apparatus of claim 26, further comprising means for assigning a user device to the wide beam based upon a velocity of the user device, wherein the velocity is determined by an accelerometer in the user device.

31. The apparatus of claim 26, further comprising means for indicating a preference for the at least one beam from the predetermined set of beams for a user device in a request.

32. A non-transitory computer-readable medium having stored thereon computer-executable instructions for:

generating at least one narrow beam;

generating a wide beam, wherein the at least one narrow beam and the wide beam are separate beams;

assigning user devices to at least one beam from a predetermined set of beams, the set of beams comprising the at least one narrow beam and the wide beam, wherein assigning the user devices to the at least one narrow beam comprises scheduling a first user device using a spatial division multiplexing (SDM) scheduling technique and scheduling a second user device using a multiple-in multiple-out (MIMO) scheduling technique;

reassigning at least one user device from a narrow beam to the wide beam if channel quality information is lower than a threshold value;

wherein the at least one narrow beam comprises a first cluster of narrow beams and a second cluster of narrow beams, wherein a first dominant direction of the first cluster is different from a second dominant direction of the second cluster; and

scheduling the first and second user devices simultaneously, using said SDM scheduling technique and said MIMO scheduling technique, by employing the first cluster of narrow beams and the second cluster of narrow beams.

33. The non-transitory computer-readable medium of claim **32**, further comprising instructions for scheduling communications for the user devices based upon a spatial division multiplexing, multiple input multiple output (MIMO) or opportunistic beamforming scheduling technique.

34. The non-transitory computer-readable medium of claim **32**, further comprising instructions for generating the wide beam using a cyclic delay diversity scheme.

35. The non-transitory computer-readable medium of claim **32**, further comprising instructions for transmitting broadcast control transmissions over the wide beam.

36. The non-transitory computer-readable medium of claim **32**, further comprising instructions for modifying the direction of the at least one narrow beam based upon a pattern of communication of the user devices.

37. The non-transitory computer-readable medium of claim **32**, wherein the channel quality information comprises a channel quality indicator.

38. The non-transitory computer-readable medium of claim **32**, further comprising instructions for assigning a user device to the wide beam based upon a velocity of the user device, wherein the velocity is determined by an accelerometer in the user device.

39. A processor that executes instructions for enhancing performance for a wireless communication environment, the instructions comprising:

generating at least one narrow beam;

generating a wide beam, wherein the at least one narrow beam and the wide beam are separate beams;

assigning user devices to at least one beam from a predetermined set of beams, the set of beams comprising the at least one narrow beam and the wide beam, wherein assigning the user devices to the at least one narrow beam comprises scheduling a first user device using a spatial division multiplexing (SDM) scheduling technique and scheduling a second user device using a multiple-in multiple-out (MIMO) scheduling technique,

reassigning at least one user device from a narrow beam to the wide beam if channel quality information is lower than a threshold value,

wherein the at least one narrow beam comprises a first cluster of narrow beams and a second cluster of narrow beams, wherein a first dominant direction of the first cluster is different from a second dominant direction of the second cluster; and

scheduling the first and second user devices simultaneously, using said SDM scheduling technique and said MIMO scheduling technique, by employing the first cluster of narrow beams and the second cluster of narrow beams.

40. The processor of claim **39**, further comprising instructions for scheduling communications for the user devices based upon a spatial division multiplexing, multiple input multiple output (MIMO) or opportunistic beamforming scheduling technique.

41. A mobile device that facilitates communicating over a wireless network, comprising:

a component configured to request assignment of the user device to at least one beam from a predetermined set of beams, the set of beams comprising at least one narrow beam and a wide beam, wherein the component is also configured to request reassignment of the user device from the at least one narrow beam to the wide beam if channel quality information is lower than a threshold value, and wherein the at least one narrow beam and the wide beam are separate beams;

wherein requesting assignment comprises transmitting an indication of the at least one beam;

a transmitter that transmits the requests to a base station;

a first cluster of antennas, wherein a first cluster of narrow beams employs the first cluster of antennas; and

a second cluster of antennas, wherein a second cluster of narrow beams utilizes the second cluster of antennas, wherein a first dominant direction of the first cluster is different from a second dominant direction of the second cluster, and wherein the first and second user devices are scheduled simultaneously, using said SDM scheduling technique and said MIMO scheduling technique, by employing the first cluster of narrow beams and the second cluster of narrow beams.

42. The mobile device of claim **41**, wherein the device is at least one of a cellular phone, a smartphone, a handheld communication device, a handheld computing device, a satellite radio, a global positioning system, a laptop, and a PDA.

43. The method of claim **1**, further comprising assigning a third user device to the wide beam while at least one of the first and second user devices is assigned to the narrow beam.

44. The processor of claim **39**, the instructions further comprising:

prior to assigning, transmitting a transmission containing information indicative of the at least one beam.

45. The non-transitory computer-readable medium of claim **32**, further comprising instructions for:

prior to assigning, transmitting a transmission containing information indicative of the at least one beam.

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